

Conclusion: Accurate midV-CT can be generated using freeware. This opens the prospect for its use in our clinical practice, allowing treatments in the upper abdomen with more adequate CTV-to-PTV margins. For lung cancer patients the approach should work even better due to the higher contrast images.

Poster: Physics track: (Quantitative) functional and biological imaging

PO-0919

Optimal respiratory gated FDG-PET for characterizing intra-tumour heterogeneity in lung cancer

J. Bussink¹, W. Grootjans², F. Tixier³, C. Van der Vos², D. Vriens⁴, C. Cheze Le Rest⁵, W. Oyen², L.F. De Geus-Oei⁴, D. Visvikis⁶, E. Visser²

¹Radboud University Medical Center, Radiation Oncology, Nijmegen, The Netherlands

²Radboud University Medical Center, Department of Radiology and Nuclear Medicine, Nijmegen, The Netherlands

³University Hospital Poitiers-, Department of Nuclear Medicine-, Poitiers, France

⁴Leiden University Medical Center, Department of Radiology and Nuclear Medicine, Leiden, The Netherlands

⁵University Hospital Poitiers-, Department of Nuclear Medicine, Poitiers, France

⁶University of Brest, INSERM- UMR1101- LaTIM, Brest, France

Purpose or Objective: Radiotracer uptake patterns in FDG-PET through computation of textural features can be used to improve characterization of lung cancer lesions for disease prognostication and response monitoring and tumor delineation purposes. Respiratory motion artefacts cause lesion blurring resulting in loss of intra-tumour heterogeneity. We have investigated the effect of respiratory gating on the recovery of intra-tumour heterogeneity.

Material and Methods: FDG-PET/CT imaging was performed in 70 lung cancer patients. Amplitude-based optimal respiratory gating (ORG) was performed on bed positions covering the thorax. The duty cycle (percentage of the total PET data) used for image reconstruction of ORG images was 35%. Non-gated images were reconstructed using 126 seconds of PET data, yielding similar noise characteristics as ORG. Lesion segmentation was performed using the fuzzy locally adaptive Bayesian (FLAB) algorithm. Four heterogeneity parameters (entropy, dissimilarity, zone percentage (ZP), and high energy emphasis (HIE)), which have previously shown to be robust and associated with survival in lung cancer, were calculated in non-gated and ORG images.

Results: Respiratory gating did not result in statistically significant differences in the heterogeneity parameters. Sub-group analysis revealed a significant effect of ORG on the heterogeneity parameters of lesions in the lower lobes. The mean increase for entropy, dissimilarity, ZP and HIE, considering lesions in the lower lobes was $1.3 \pm 1.5\%$ ($p=0.02$), $11.6 \pm 11.8\%$ ($p=0.006$), $2.3 \pm 2.2\%$ ($p=0.002$), and $16.8 \pm 17.2\%$ ($p=0.006$) respectively. For the centrally located lesions, the mean increase for entropy, dissimilarity, ZP and HIE was $0.58 \pm 3.7\%$ ($p=0.6$), $5.0 \pm 19.0\%$ ($p=0.4$), $0.59 \pm 4.0\%$ ($p=0.9$), and $4.4 \pm 27.8\%$ ($p=0.4$), respectively. Lesions in the upper lobes showed a mean increase of $-0.35 \pm 1.8\%$ ($p=0.3$), $-1.0 \pm 7.7\%$ ($p=0.3$), $-0.4 \pm 2.7\%$ ($p=0.5$), $-1.7 \pm 13.2\%$ ($p=0.4$), for entropy, dissimilarity, ZP and HIE, respectively. There was no significant correlation between lesion volume and the change in parameters between non-gated and ORG images.

Conclusion: Results from this study indicate that ORG significantly impacts characterisation of intra-tumour heterogeneity, particularly for lesions in the lower lung lobes. This suggests that adequate management of respiratory motion artefacts is important for improving characterisation of intra-tumour heterogeneity in PET.

PO-0920

Early prediction of individual response in neo-adjuvant adaptive Radiochemotherapy for rectal cancer

R. Raso¹, P. Passoni², A. Palmisano³, C. Fiorino¹, G.M. Cattaneo¹, F. De Cobelli³, A. Esposito³, P. Mangili¹, N. Slim², N.G. Di Muzio², R. Calandrino¹

¹San Raffaele Scientific Institute, Medical Physics, Milano, Italy

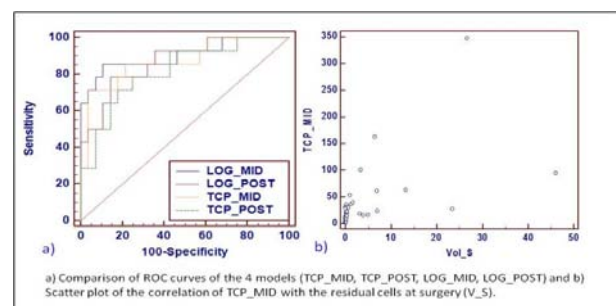
²San Raffaele Scientific Institute, Radiotherapy, Milano, Italy

³San Raffaele Scientific Institute, Radiology, Milano, Italy

Purpose or Objective: Developing a radiobiologically consistent model predicting individual outcome for rectal cancer patients (RCPs) treated with an adaptive boost approach during neo-adjuvant radiochemotherapy (RCH).

Material and Methods: Forty-two RCPs were treated within a prospective observational study. CH consisted of oxaliplatin (on days: -14, 0, 14) and 5-fluorouracil (from day -14 to end) being day 0 the start of RT. All patients were treated with Helical Tomotherapy (18x2.3Gy) with an adaptive concomitant boost technique delivering 3Gy/fr on the residual gross tumor volume (GTV) in the last 6 fractions (fr), based on MRI imaging taken at fr 9. GTVs were contoured by a single radiologist on axial T2 MRI images acquired for initial planning (V_PRE), at fr 9 for the adaptive planning (V_MID) and before surgery, after a median time of 8.9 weeks after the end of RCH (V_POST). Based on a Poisson-like tumor regression model and neglecting repopulation and inter-patient variability of the removal kinetics of killed cells, the parameter $(1-\Delta V(D))^{V_PRE}$ was taken as a surrogate of tumor control probability (TCP), where $\Delta V(D)=V_MID/V_PRE$ or V_POST/V_PRE , considering D at fr 9 (TCP_MID) or at the end of RCH (TCP_POST). The discriminative power of TCP_MID/POST in predicting the pathological complete remission (pCR, n=14) was assessed by the AUC of the corresponding ROC curves. Then, two-variables logistic (LOG) models including V_PRE and $\Delta V(D)$ as covariates were also considered and the ROC curves of the four models (TCP_MID, TCP_POST, LOG_MID, LOG_POST) were compared. In addition, an estimate of the residual cells at surgery (V_S) was robustly taken as the product of the pathologically assessed fraction of viable cells and V_POST. Spearman correlation rank test was used to evaluate the correlation between the models and V_S.

Results: All models showed a high discriminative power in predicting pCR ($p\text{-value} < 0.0001$). AUCs for TCP_MID was 0.87 (specificity: 71.4%, sensitivity: 96.4%, best cut-off: 5.85), higher than TCP_POST (0.82), although the difference did not reach significance ($p=0.18$). TCP_MID/TCP_POST were also highly correlated with V_S ($R=0.77$ and $0.74, p < 0.0001$). Similar performances were found for LOG_MID/LOG_POST with AUC=0.90/0.87 and $R=0.79/0.77$. No significant differences were found when comparing TCP models against the corresponding LOG models.



Conclusion: A radiobiologically consistent model including early regression (TCP_MID) measured on T2-MRI images well predicts pCR and is strongly correlated with the estimated residual cells number after adaptive RCH; similar performances were obtained with a logistic model including V_PRE and V_MID/V_PRE. The corresponding models using V_POST showed a slightly, statistically not significant, worse

discriminative power. The results showed that MRI volumes measured before and during RCH have a great potential to better individualize adaptive RCH.

PO-0921

Free-breathing dynamic contrast enhanced MRI of lung cancer

S. Kumar^{1,2,3}, G. Liney^{1,2,3,4}, R. Rai³, D. Moses^{5,6}, C. Choong⁷, L. Holloway^{1,2,3,4,8}, S. Vinod^{1,3}

¹The University of New South Wales, South Western Clinical School, Sydney, Australia

²Ingham Institute of Applied Medical Research, Medical Physics, Sydney, Australia

³Liverpool and Macarthur Cancer Therapy Centre, Radiation Oncology, Sydney, Australia

⁴University of Wollongong, Centre for Medical Radiation Physics, Wollongong, Australia

⁵Prince of Wales Hospital, Department of Medical Imaging, Sydney, Australia

⁶The University of New South Wales, School of Computer Science and Engineering, Sydney, Australia

⁷Liverpool and Macarthur Cancer Therapy Centre, Radiation Oncology, Liverpool, Australia

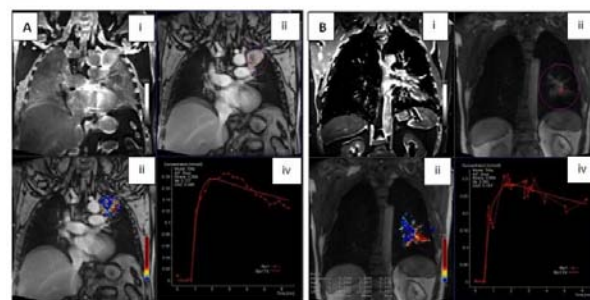
⁸University of Sydney, Institute of Medical Physics, Sydney, Australia

Purpose or Objective: Dynamic contrast enhanced (DCE) MRI is becoming an increasingly important tool for assessing tumour response in Radiotherapy (RT). Important characteristics are spatial and temporal resolution and in lung this is further complicated by the effects of respiratory motion. A common approach is to acquire fast gradient-echo imaging utilising k-space sharing to provide optimum temporal resolution and to collect data during short 'windows' of breath-holds over the time course. However patient compliance during breath hold manoeuvres can lead to tumour displacement and introduce error in analysis. Radial acquisitions can alleviate motion by oversampling the centre of k-space albeit with reduced temporal resolution. The purpose of this study was to evaluate whether such a 'stack-of-stars' acquisition can be used with high enough resolution for the DCE sequence to provide a complete free breathing RT planning protocol in lung patients.

Material and Methods: Institutional review board approval was obtained. Two patients receiving lung radiotherapy underwent DCE-MRI on our dedicated wide bore 3 Tesla system (Skyra, Siemens) using an 18 channel flexible coil and 32 channel table coil. Patients were positioned as per treatment setup with their hands above their head. Two DCE protocols were examined; a fast gradient-echo sequence employing k-space sharing (TWIST) acquired as 5 breath-hold periods of 20s each with a spatial and temporal resolution of 1.5 mm/3 s; and a completely free breathing scan performed using a radial acquisition (StarVIBE) with a resolution of 1.8 mm and 14 s. The acquisition time was approximately 6 minutes for both sequences. In both cases a rapid pre-contrast measurement of T1 was acquired using the same sequence and two flip angles. Analysis included calculation of T1 map and a two-compartment model fit to the data (Tissue4D, Siemens) to provide pixel-by-pixel maps of the perfusion rate constant.

Results: Figure 1 shows images and analysis taken from both sequences. Viewing DCE data in a cine loop revealed large movement between frames for TWIST compared to StarVIBE. A comparison of signal-time plots shows a typical result where failure to maintain and reproduce breath hold has produce large variation and discontinuities in the dataset. As a result the goodness-of-fit (χ^2) was better for StarVIBE (0.05) than the corresponding value using TWIST (0.16). Although temporal resolution is much poorer with the StarVIBE sequence, it was sufficient to sample the early upslope phase of the contrast agent. General image quality was assessed with radial and motion artefacts scored as being negligible.

Figure1



(A) StarVIBE; (B) TWIST (i) T1 map; (ii) DCE image; (iii) Ktrans; (iv) Time-enhancement curve

Conclusion: These initial results show that use of a radial k-space trajectory as a method of motion compensation provides a DCE scan of sufficient image quality and temporal resolution which can be used as part of a complete free breathing lung protocol.

PO-0922

Are planning CT radiomics and cone-beam CT radiomics interchangeable?

J.E. Van Timmeren¹, R.T.H. Leijenaar¹, W. Van Elmpt¹, P. Lambin¹

¹Maastricht University Medical Centre, GROW-School for Oncology and Developmental Biology - Department of Radiation Oncology - MAASTRO clinic, Maastricht, The Netherlands

Purpose or Objective: Radiomic image features derived from conventional treatment planning CT images have already been shown to have prognostic information. For cone-beam CT (CBCT) imaging during radiotherapy this has not yet been described. Due to the fact that a CBCT image is acquired prior to each fraction it has the potential to monitor response to treatment. The goal of this study was to investigate the stability and the correlation between radiomic features derived from planning CT vs. CBCT and between CBCTs of different fractions.

Material and Methods: A total of 27 stage II-III NSCLC patients who received radiation therapy were included in this study. For each patient a treatment planning CT scan was acquired and CBCT scans were obtained prior to each fraction. The planning CT (CT1), the CBCT of the first (CBCT-FX1) and second fraction (CBCT-FX2) were used in this study. CBCT images were registered to CT1 using automatic rigid registration prior to feature extraction. In total, 149 radiomic image features were extracted of different feature groups: I) tumor intensity, II) texture, III) Laplacian of Gaussian. The third group consists of filtered first order features and the group was subdivided into 10 groups, according to different LoG filter standard deviations ranging from 0.5 mm to 5 mm with a 0.5 mm interval. Since a rigid registration was used, features related to shape and volume were not analyzed. The correlation between features derived from (1) CT1 and CBCT-FX1 and (2) CBCT-FX1 and CBCT-FX2 were analyzed. Correlations were calculated using an intraclass correlation coefficient ICC(2,1). An ICC-value above 0.9 was considered a good agreement.

Results: For 26% of the 149 analyzed radiomics features, the ICC-value was higher than 0.9 for CT1 compared to CBCT-FX1 (Figure). The ICC-value was above 0.9 for 81% of the features when comparing CBCT-FX1 to CBCT-FX2. Specifically for the feature group 'texture', one of the 44 features had an agreement between CT1 and CBCT-FX1 that was higher than 0.9, but 35 out of 44 did show agreement for CBCT-FX1 vs. CBCT-FX2. For 'tumor intensity', 2 out of 15 features showed a large correlation between CT1 and CBCT-FX1 higher than 0.9, whereas 10 out of 15 features showed agreement higher than 0.9 between CBCT-FX1 and CBCT-FX2 (ICC>0.8 for all). All features with ICC above 0.9 for CT1 vs. CBCT-FX1 also showed high correlation between CBCT-FX1 and CBCT-FX2.